Modeling Smart Sensors on top of SOSA/SSN and WoT TD with the Semantic Smart Sensor Network (S3N) Modular Ontology

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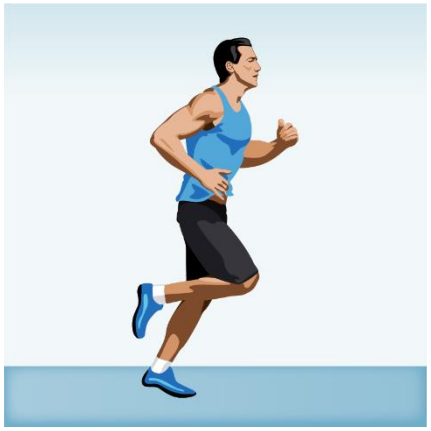
SSN-2018

Smart Sensors illustrated

Abdel
an amateur sportsman



Practices cycling

- The pedalling cadence;
- The "riding out of the saddle" (or dancing);
- The duration and the road steepness.

Practices running

- The stride number;
- The running distance;
- The average stride frequency.

Smart Sensors

- multi-functional: they can be used in multiple contexts, and are able to execute several algorithms
- their have different computation and communication profiles
- different algorithms may be selected and loaded, potentially at runtime

A knowledge engineering methodology

1. Analyze the domain
2. Develop scenarios.
3. Extract competency questions from the scenarios to define the scope of the ontology.
4. Choose which of the existing ontologies to reuse.
5. Develop the ontology.
6. Qualitatively validate the ontology by showing how it answers the competency questions.

Step 1: What is a Sensor

[Compton et al. 2009] A sensor observes the physical property (e.g., temperature, depth) of a feature of interest (e.g., a lake) and report observations

[Le-Phuoc & Hauswirth, 2009] data sources which produce a sequence of data items over time (a data stream).

[Neuhaus & Compton, 2009] source producing a value representing a phenomenon in a particular field.

[SOSA/SSN, 2017] A [Basic-] Sensor is a Device, agent (including humans), or software (simulation) involved in, or implementing, a Procedure. [Basic-]Sensors respond to a Stimulus, e.g., a change in the environment, or Input data composed from the Results of prior Observations, and generate a Result. [Basic-]Sensors can be hosted by Platforms.

Step 1: What is a Smart Sensor

[IEEE 1451] A Smart-Sensor hosts a set of basic sensors together with communicating components, and a specific component, usually a micro-controller, to condition and process the signal by executing embedded functions before transmitting output data to the control network. Some Smart-Sensors can be configured in a custom manner.

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Our definition:

The concept of a smart sensor is based on its ability to:

(1) acquire data thanks to its embedded sensors,

(2) process this data thanks to one or more algorithms its micro-controller implements,

(3) output and communicate indicator values,

(4) be reprogrammable and reconfigurable.

Step 1: What is a Smart Sensor

	hosts	implements	makes
Basic-Sensor	-	One top procedure	Observations
Smart-Sensor	some Basic-Sensors, a micro-controller, a communicating component	Several procedures usable in different contexts	Algorithm Executions

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Step 2: scenarios (involv. LIS2DH 3-Axis Accelerometer sensors)

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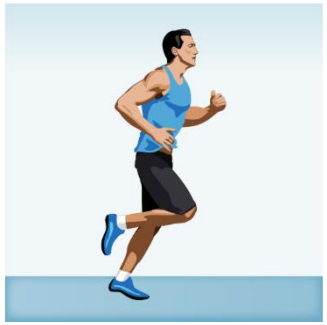


"App-store of algorithms"

Beth
A professional biathlete

Change algo accod. context

Charles
An elderly person

wristband helping constant monitoring.

Step 3: competency questions

Operational phase

- CQ1: What are the components of the Smart Sensor: its Basic-Sensors, microcontroller, and communicating component?
- CQ2: What is the set of algorithms a micro-controller implements?
- CQ3: What indicator did the algorithm output a value for?
- CQ4: For a given result output by the micro-controller, what algorithm has been used?
- CQ5: If an error occurs when executing an algorithm, What is the reason and the origin of that error?
- CQ6: How can one access or subscribe to the output of the micro-controller?

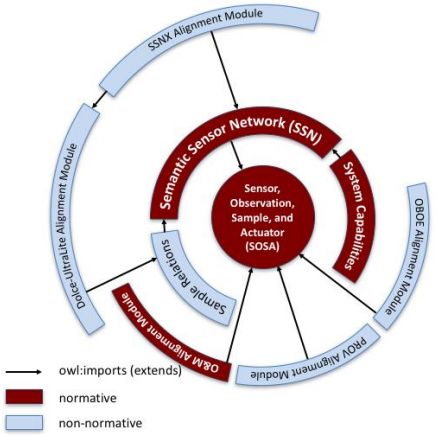
Step 3: competency questions

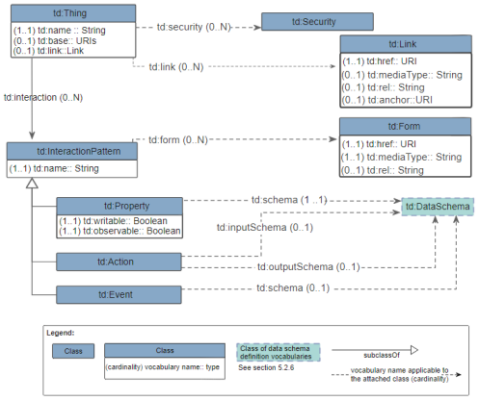
Reconfiguration Phase

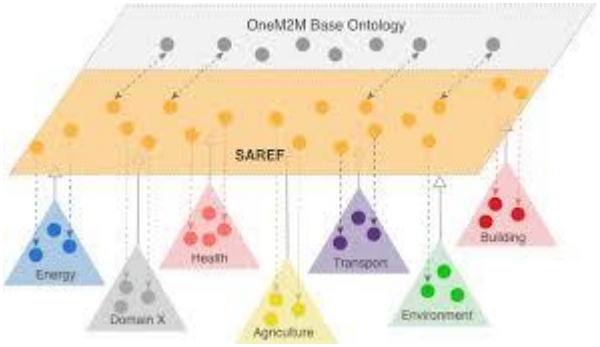
- CQ7: For a given algorithm, what is the context of use?
- CQ8: For a given algorithm, what are the indicator it outputs?
- CQ9: For a given algorithm, what are the properties it requires as input?
- CQ10: What are the capabilities of a micro-controller?
- CQ11: For a given algorithm, what are the minimal requirements for the microcontroller to execute it?
- CQ12: Can a micro-controller implement a given set of algorithms?
- CQ13: How can one change the set of algorithms a micro-controller implements?

Step 4: Existing ontologies to reuse?

- ontologies designed to model sensors and the IoT
- standards or will soon be







W3C SOSA/SSN

W3C WoT TD

ETSI SAREF

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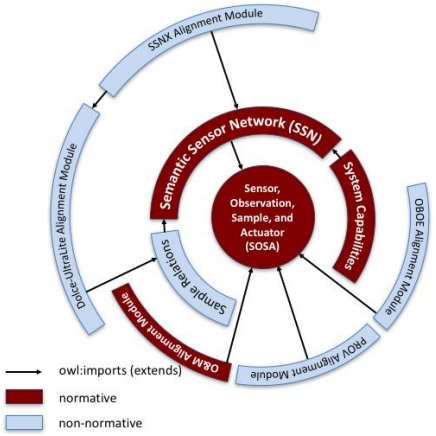
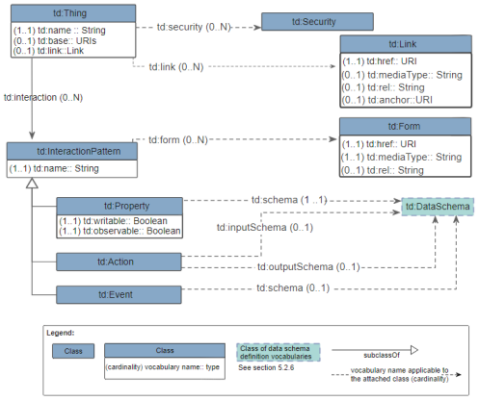
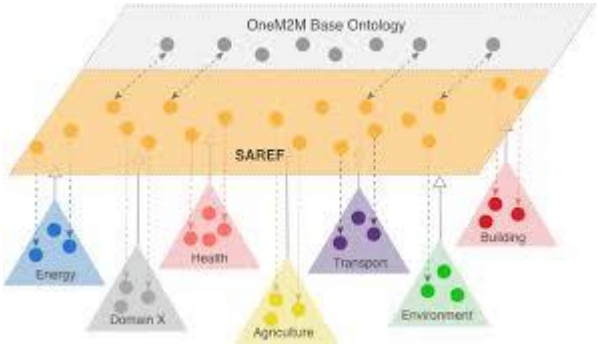




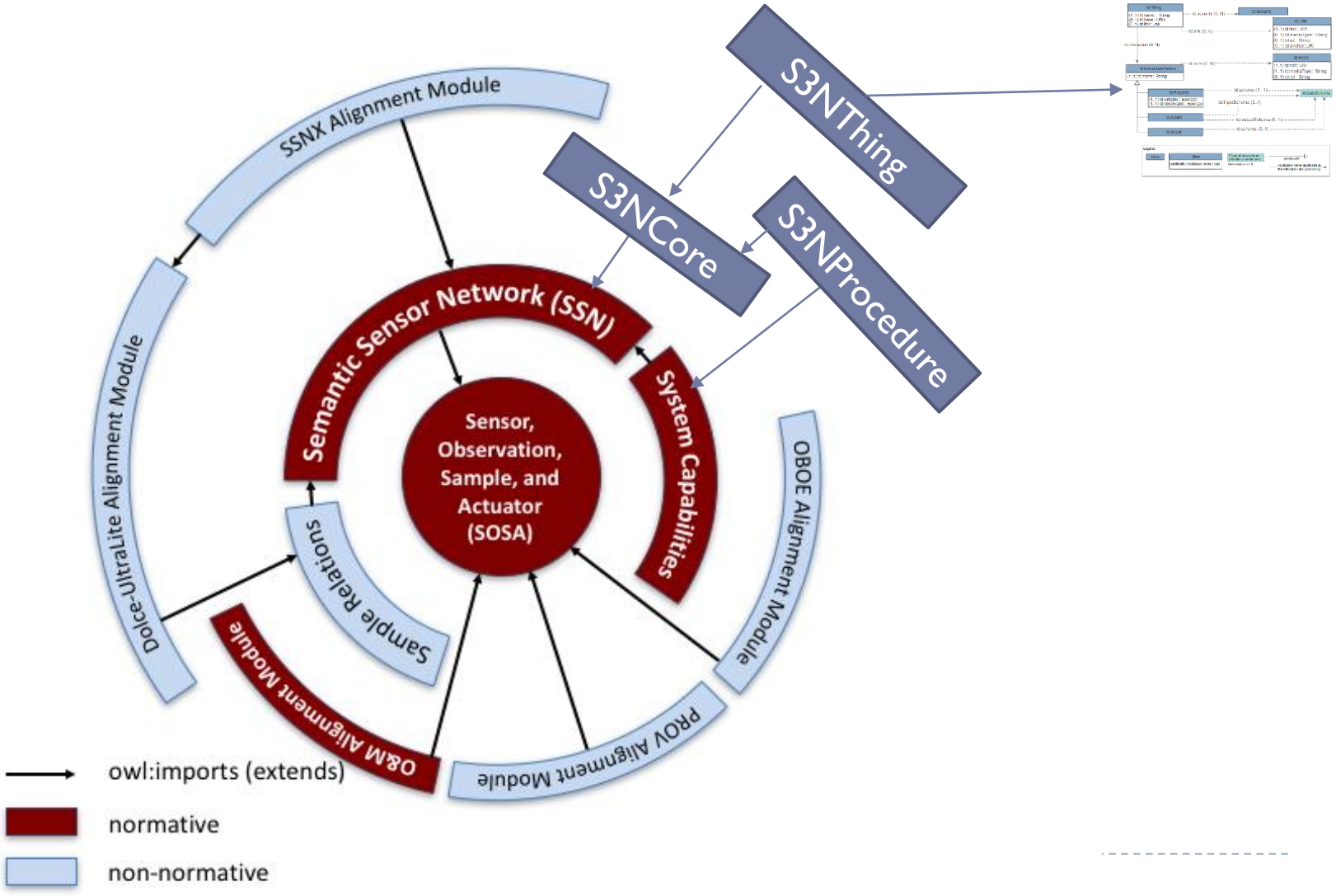


W3C SOSA/SSN

W3C WoT TD

ETSI SAREF
+ SEAS (STF 556)

Step 5: Develop the S3N ontology



S3N-Core Module https://w3id.org/s3n/S3NCore

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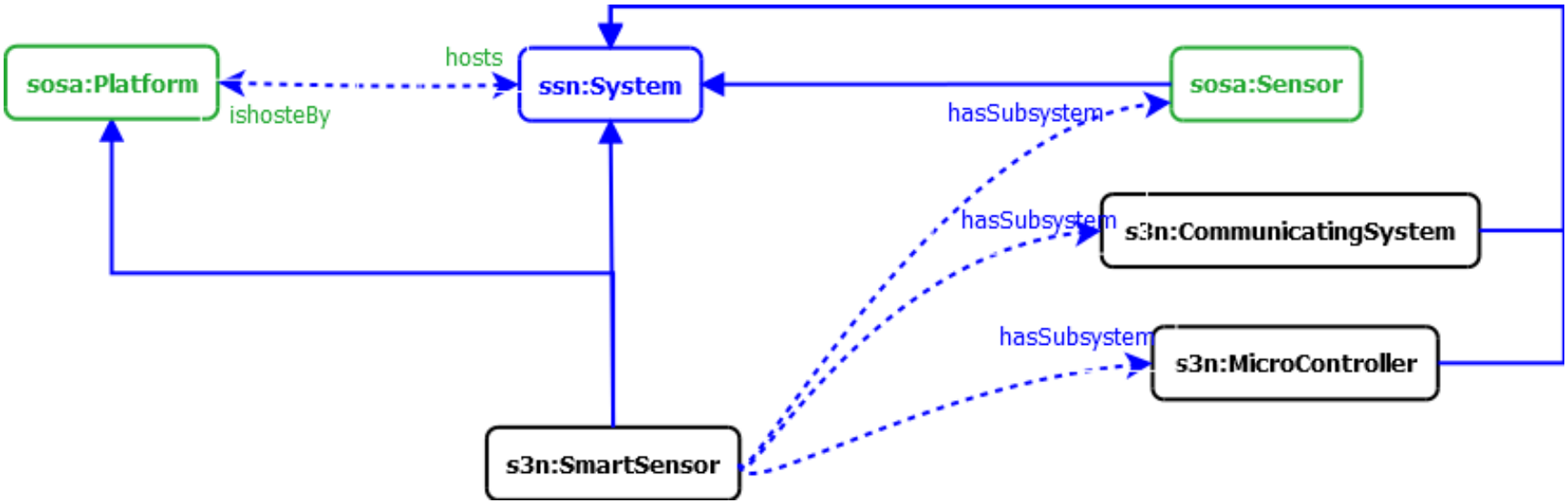
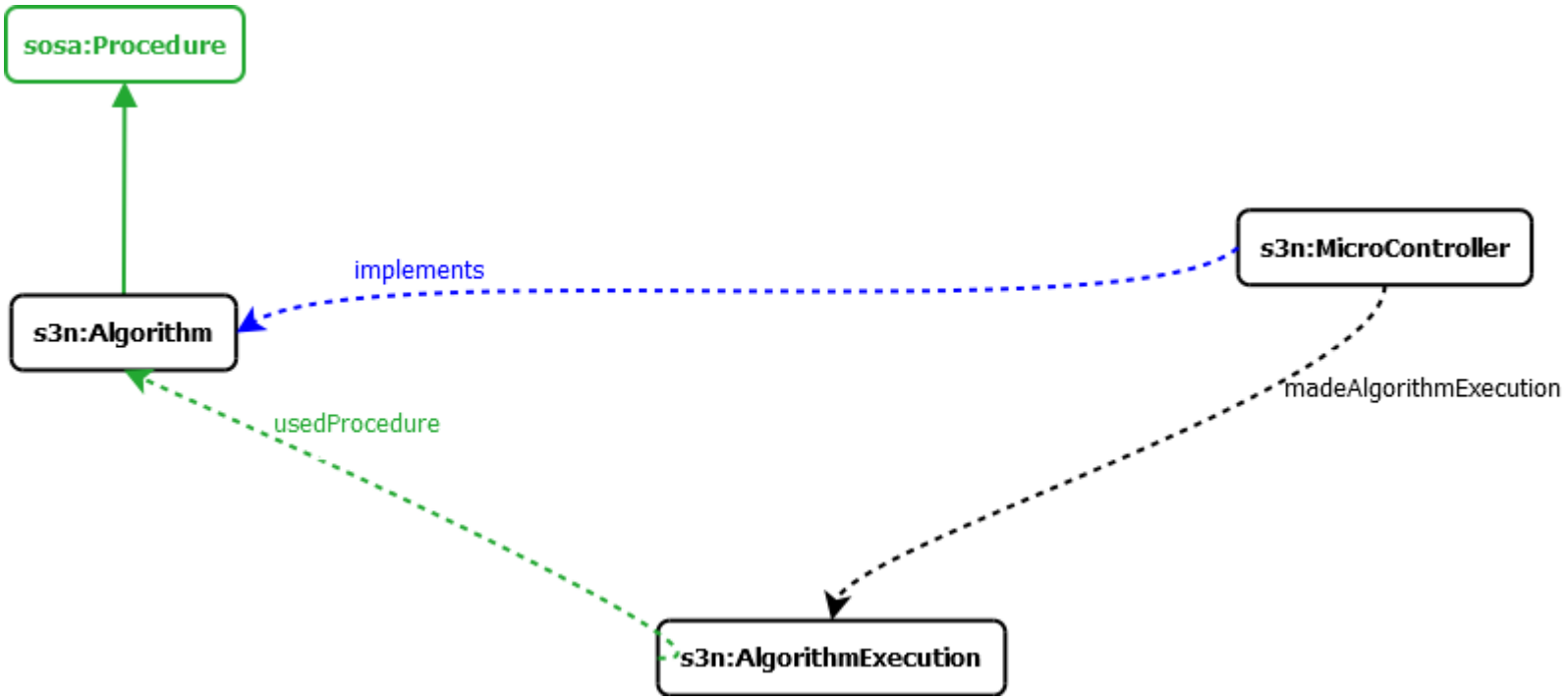


Smart-Sensors Composition

- A SmartSensor is composed of
  - 1 or n Sensors;
  - 1 MicroController
    - implements different Procedures, and make Executions of these Procedures on the result of the Observations these Sensors make to output a resulting value for some Indicator.
  - CommunicatingSystem
    - communicates this value

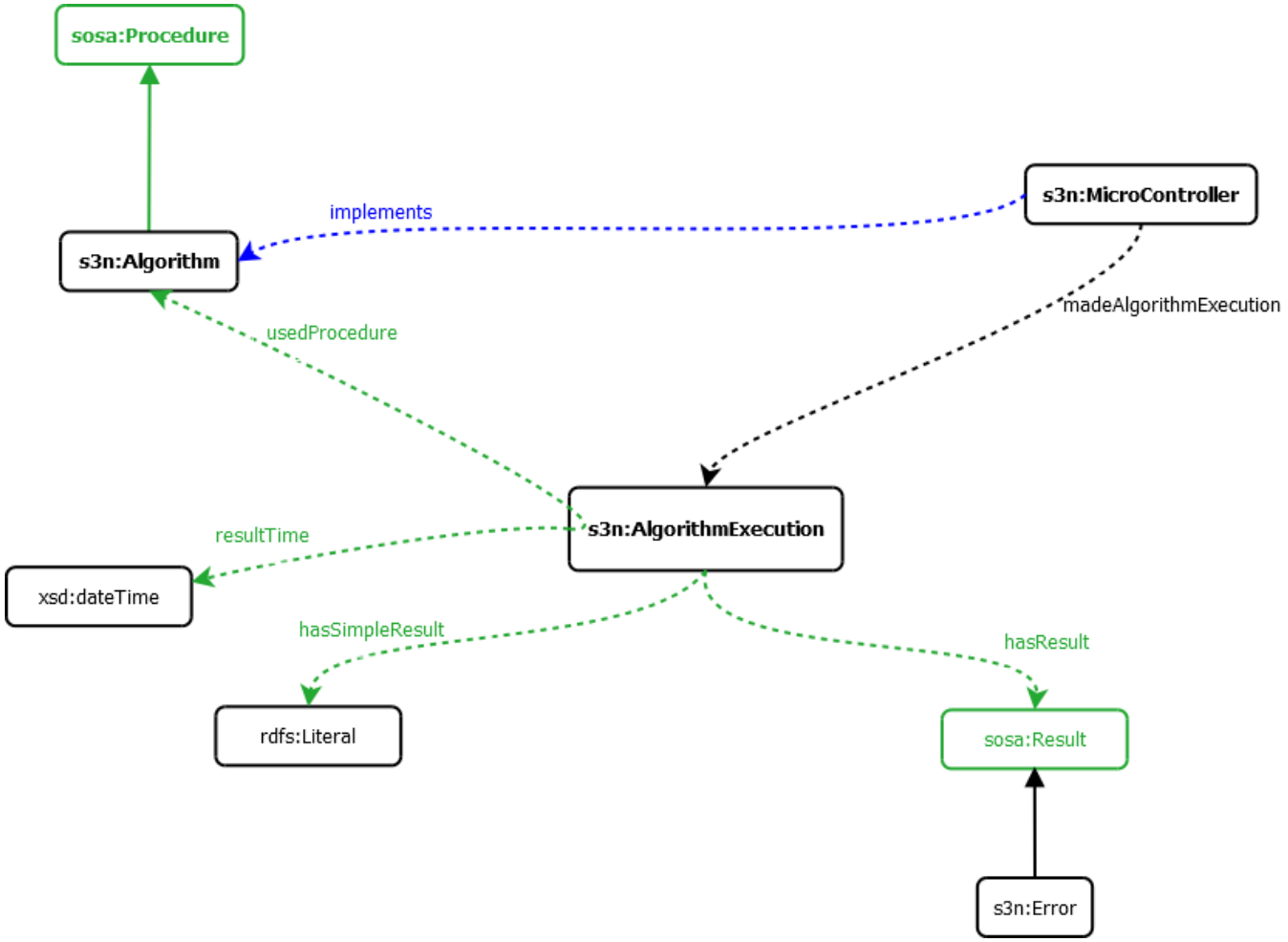
S3N-Core Module https://w3id.org/s3n/S3NCore

Algorithms and their Executions



S3N-Core Module

Result



S3N-Core Module

Result

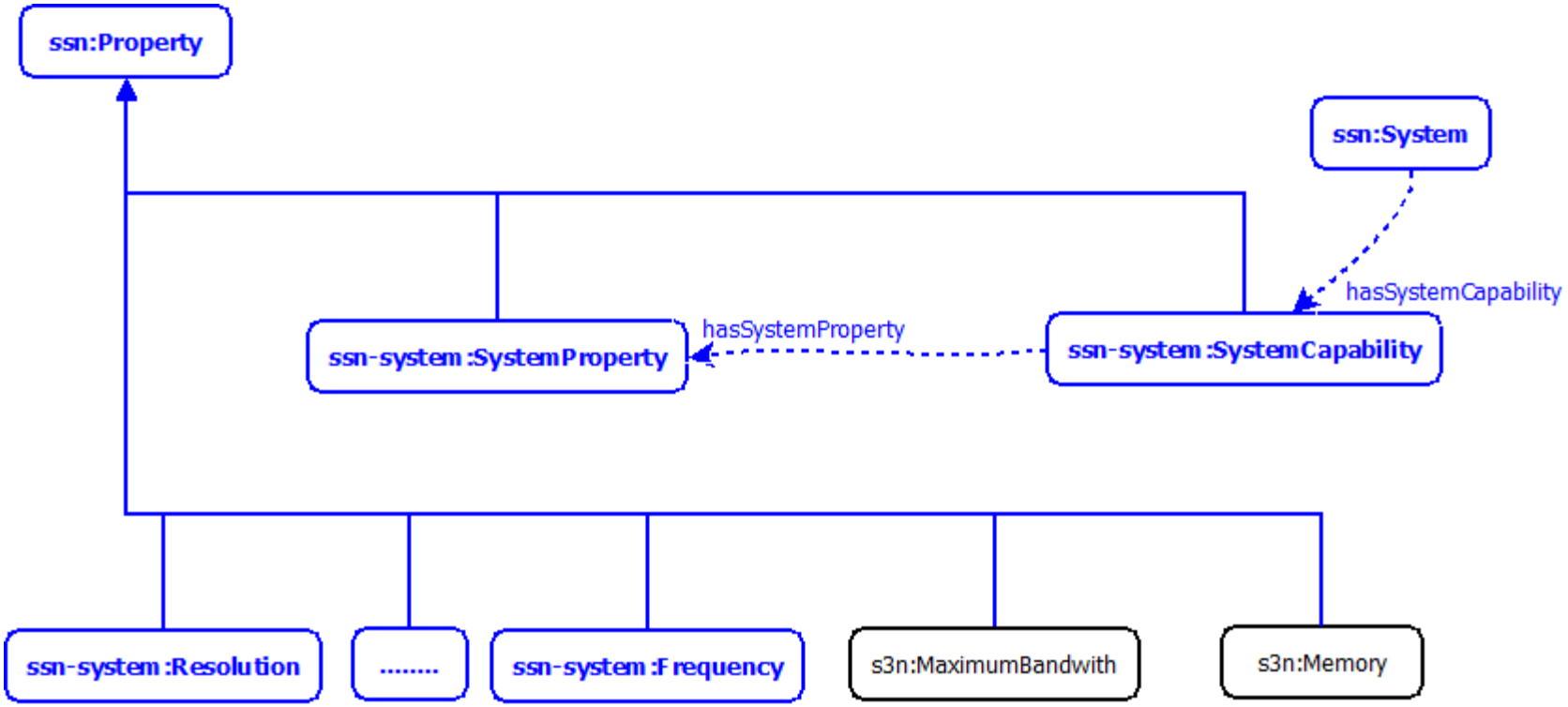
```
<smartSensor1> sosa:hasSubSystem <uc1> .
<uc1> a s3n:MicroController ;
  sosa:implements <avgTemp#24H>, <avgTemp#1Y> ;
  sosa:madeAlgorithmExecution <exec1>, <exec2> .

<exec1> a s3n:AlgorithmExecution ;
  sosa:usedProcedure <avgTemp#24H> ;
  sosa:hasSimpleResult "17.0 DEG"^^cdt:ucum .

<exec2> a s3n:AlgorithmExecution ;
  sosa:usedProcedure <avgTemp#1Y> ;
  sosa:hasResult [ a s3n:Error ; s3n:cause <insufficientMem> ] .
```

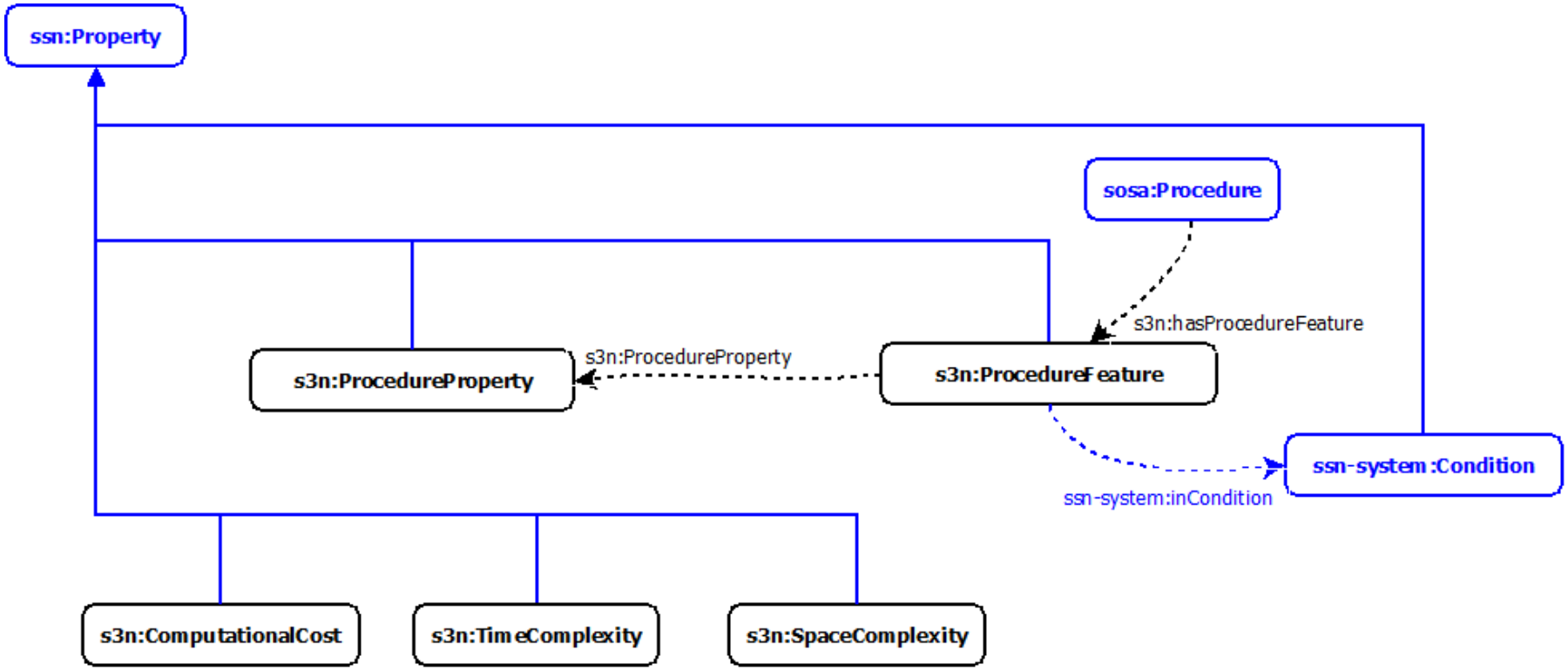
S3N-Procedure Module

Capabilities of System



S3N-Procedure Module

Features of Procedure



S3N-Thing Module

Use

- imports S3N-core and TD;
- describes possible interactions with a Smart-Sensor,;
- It contains the alignments that were proposed between SSN and TD concepts

```
<smartsensor01> a s3n:SmartSensor ;
   td:interaction [ a td:Property ;
     rdfs:comment "How to observe the algorithm execution results."@en ;
     td:observable true ;
     td:link [ td:href
         <wss://192.168.24.75/> ; td:mediaType "application/json" ] ] .
```

Conclusion

- S3N Ontology describes Smart-Sensors and their adaptabilities;
- S3N is the first ontology that
  - Formalizes a proposed alignment between SOSA/SSN and TD;
  - Adapts the pattern defined in the SSN System Capabilities module to model properties of other things than Systems;
  - Reuses the SEAS innovative publication scheme so as to be published as three ontology modules each defining terms in the same namespace.